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Application No. 09/856,209	Filing Date 5/18/2001	Examiner Matthew J. Song	Customer No. 24628	Group Art Unit 1722

Invention: SILICON CRYSTAL AND PRODUCT METHOD FOR SILICON SINGLE CRYSTAL WATER

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Docket No. 1110/82822

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In Re Application Of: Kozo Nakamura

Application No.	Filing Date	Examiner	Customer No.	Group Art Unit	Confirmation No.
09/856,209	5/18/2001	Matthew J. Song	24628	1722	6736

Invention: **SILICON CRYSTAL AND PRODUCTION METHOD FOR SILICON SINGLE CRYSTAL WATER**

COMMISSIONER FOR PATENTS:

Transmitted herewith in triplicate is the Appeal Brief in this application, with respect to the Notice of Appeal filed on **April 6, 2005**

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Dated: **October 24, 2005**

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PATENT
Attorney Docket No. 1110/82822

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: Kozo Nakamura	)	Confirmation No.: 6736
Serial No.: 09/856,209	)	**EXPRESS MAIL LABEL NO.: EV 731 141 912 US**
Filed: May 18, 2001	)	I hereby certify that this paper is being deposited with the United States Postal Service as Express Mail in an envelope addressed to: Mail Stop Appeal Brief - Patents, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 23313-1450.
Title: SILICON CRYSTAL AND PRODUCTION METHOD FOR SILICON SINGLE CRYSTAL WAFER	)	**October 24, 2005**
Examiner: Matthew J. Song	)	
Art Unit: 1722	)	Daniel M. Gurfinkel, (34,177)

APPLICANT'S REPLY BRIEF UNDER 37 C.F.R. § 41.41

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REPLY BRIEF

Responsive to the Examiner's Answer mailed August 24, 2005, it is respectfully submitted that:

1. The Examiner Continues to Improperly Apply the Iida et al. Patent in Rejecting Claims 17-20.

THE EXAMINER CONTINUES TO IMPROPERLY APPLY THE IIDA ET AL. PATENT IN REJECTING CLAIMS 17 AND 18

1. The Present Invention

The present invention was made based on the discovery that a GOI C mode factor (hereinafter simply referred to as "C mode factor") of the silicon single crystal has a relationship among the variable of (G1 edge/G1 center) and the variable of (OSF ring inner diameter/crystal diameter) and (G1 center×G2 center). The silicon single crystal having the C mode factor of 60% or more can be produced firmly by satisfying the numeric value range of the present invention. Iida et al. do not describe at all the C mode factor of the silicon single crystal. Moreover, as a matter of course, Iida et al. neither describe nor suggest that there are relationships among the C mode factor of the silicon single crystal and the above respective variables.

The present invention was made based on the discovery of the effectiveness of the silicon single crystal having not only a defect-free region but also a void defect region and an OSF ring generating region coexisting therein, and is to produce the silicon single crystal in which the defect-free region, the void defect region and the OSF ring generating region coexist. Conventionally, wafers are produced by using a defect-free silicon single crystal like in Iida et al. However, when making the silicon single crystal to be defect-free, a pulling control becomes difficult. When producing a wafer by using the silicon single crystal in which not only the defect-free region but also the void defect region and the OSF ring generating region coexist like in the present invention, there is an effect that the silicon single crystal can be produced by an easy pulling control.

This will be more clearly shown in explaining further the two conditions expressed in Claim 17.

A. FURTHER EXPLANATION OF THE CONDITIONS (1) AND (2) OF CLAIM 17

(a) As to Condition (2)

The C mode factor is affected by the void defect. It is known that the more the number of the defects is, the more the C mode factor decreases. Therefore, to make the C mode factor 60% or more, it is necessary to suppress the number of defects in the wafer to a certain value or less.

Since the number of defects is determined according to (area × defect density), it is considered that the C mode factor is affected by "***I*** the area of the region where void defects exist (the area of the interior of the OSF ring)" and "***II*** the defect density in the region where the void defects exist". Therefore, to suppress the number of the defects, it is necessary to reduce the ***II*** if the ***I*** is large, or conversely, it is necessary to reduce the ***I*** if the ***II*** is large.

When the (OSF ring inner diameter/crystal diameter) is large, it means that the ***I*** is large. That is, it is considered that the larger the (OSF ring inner diameter/crystal diameter) is, the more the C mode factor is lowered. This is a result which can be easily led.

The main point of the present invention is the discovery of the factor for changing the defect density of the ***II***. The present inventors have discovered, by various experiments and searches, the properties that the larger the (G1×G2) becomes the more the density of the defects is increased and the C mode factor is lowered.

The relationship between (G1×G2) and (OSF ring inner diameter/crystal diameter) shown in FIGS. 3(B)-3(D) of the present application shows the upper limit of (G1×G2) for every (OSF ring inner diameter/crystal diameter). In FIGS. 3(B)-3(D), when taking note of a predetermined C mode factor, the more (OSF ring inner diameter/crystal diameter) is increased, the more the upper limit is decreased. As a result of the experiments by taking note of the C mode factor of 60% or more, the straight line

of "$1.06\times(G1center\times G2\ center)^{-0.2}$" shown in the FIGS was obtained as a borderline. That is, the straight line of "$1.06\times(G1center\times G2\ center)^{-0.2}$" becomes the border for determining the defect density upper limit for every OSF ring inner diameter, to make the C mode factor 60% or more.

The relationship between the G1 and the defect density (and C mode factor) has not been known at the time the present application was filed, but has become clear by the present invention. Further, when considered by including the G2 and the OSF ring diameter, the relationship with each other becomes complicated. Therefore, the present invention would not have been predicted even in a qualitatively prior to the time of filing the present invention.

FIGS. 10A and 10B of Iida et al. show the change in the OSF ring inner diameter, but the specification of Iida et al. does not describe any information regarding the defect density in the OSF ring. Namely, it is considered that Iida et al. disclose the information regarding the above-mentioned ***I***, but do not disclose the information regarding the above-mentioned ***II***. Further, the defect density changes also by the G2 not disclosed in Iida et al. From the foregoing, the C mode factor cannot be optimized by the adjustment of only the pulling speed as in Iida et al.

(b) As to Condition (1)

The condition (2) is satisfied only in the range of the condition (1), that is,$1.15\leqq$ G1 edge/G1 center$\leqq$ 1.25. This G1 edge/G1 center represents the uniformity of G1 in a radial direction. The nearer G1 edge/G1 center approaches "1", the smaller the difference between G1 of the crystal center and G1 of the edge portion becomes. According to the change in G1 edge/G1 center, the manner of change of the OSF ring diameter to the pulling speed and the distribution of the defect density in the OSF ring are changed. When there is a difference in G1 in the plane (in a section crossing perpendicular to the pulling direction of an ingot), a difference is produced also in the defect density.

That is, the fact that the condition (2) satisfies only in the range of the condition (1) means that the condition (2) satisfies only in the case that the uniformity of G1 is suitable in the plane. This reason is considered as below.

According to the explanation in the above (a), when the above-mentioned ***I*** is reduced, the number of defects is reduced. However, in fact, even if the ***I*** is reduced, the number of defects cannot be reduced to an extent sufficient to make the C mode factor 60% or more. If the difference in G1 excessively exists in the plane, before the OSF ring diameter is sufficiently contracted by the decrease of the pulling speed (before the defect-free region at the edge side becomes not so wide), a dislocation cluster occurs. On the contrary, if G1 is too close to the uniformity in the plane, before the change of the OSF ring diameter starts by the decrease of the pulling speed, occasionally the defect density becomes higher than the normal case, and it becomes impossible to increase the C mode factor to 60% or more.

Incidentally, in FIGS. 10A and 10B of Iida et al., G1 edge/G1 center is 1.07. This value corresponds to FIG. 3(A) of the present application. In FIG. 3(A), the C mode factor is less than 60% in the entire region. That is, it is considered that the C mode factor is less than 60% at all the positions of 0.5 to 1 in FIGS. 10A and 10B of Iida et al. On the other hand, when the numeric value shown in FIG. 8 of Iida et al. is used, Iida et al. is included in the condition of Claim 17 of the present application according to the value of G2 which is not clearly shown. Therefore, it is considered consequently that the C mode factor becomes 60% or more. However, as described in the above (a), Iida et al. do not disclose the information regarding the C mode factor at all. Therefore, from Iida et al., it is impossible to judge a technology for increasing the C mode factor to 60% or more.

In the first place, Iida et al. regard the embodiment shown in FIGS. 10A and 10B, and the embodiment shown in FIG. 8 to be the same, and consider that these are excellent in the crystal quality. However, considering the C mode factor, the crystal quality of the embodiment shown in FIGS. 10A and 10B greatly differs from the crystal quality of the embodiment shown in FIG. 8. According to Iida et al., it is better to make a difference between G1 edge and G1 center small, and if the difference is made small, the crystal quality becomes excellent. On the other hand, according to the present invention, there is

a lower limit in G1 edge/G1 center, and if the difference between G1 edge and G1 center is small, the C mode factor cannot become 60% or more. Therefore, the present invention differs from Iida et al.

Accordingly, Applicant respectfully requests that the Board reverse the decision of the Examiner finally rejecting Claims 17-20.

Respectfully submitted,
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Dated: **October 24, 2005**

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